SafeDriver – AI-Powered Real-Time Driver Monitoring & Accident Prevention System

Prepared by:

CodeCrafters Team

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Table of Contents

List of Tables

List of Figures

Document Revisions

Date	Version	Description	Author
24/12/2025	V1	Initial Progress Report 02	K.J.L. Perera
02/01/2026	V2	Modified changes I	D. S. Sandeepa
24/01/2026	V2.1	Diagram Representations	D.S. Sandeepa
05/03/2026	V2.2	Implementation Snapshots	R.U. Gonalagoda P.S. Ekanayake T.P. Denagamage

Table 1 : Document version history

Declaration

We hereby declare that this progress report 2 is our original work and does not include, without proper acknowledgment, any material previously published or submitted for a degree or diploma at any other university or institution of higher learning. To the best of our knowledge and belief, it does not contain any material written or published by another person except where such acknowledgement is made within the text.

Signature: ..... Date: 13.01.2026

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K. J. L. Perera

Signature: ..... Date: 13.01.2026

T. P. Denagamage

I have reviewed the proposal and confirm that it adheres to the provided progress report 2 outline. I hereby approve the proposal for submission.

Signature of the supervisor: ..... Date: 13.01.2026

Dr. D.D.M. Ranasinghe

Executive Summary

This Progress Report 2 documents the system design phase of the SafeDriver project. Following the successful completion of requirements analysis in Progress Report 1, this phase focuses on transforming approved requirements into detailed, implementable system designs. The report presents a comprehensive technical blueprint including system architecture, design patterns, UML diagrams, and functional prototypes for the embedded monitoring system, web dashboard, and mobile application.

Key achievements during this phase include finalization of a four-tier system architecture, design of core system components, UI/UX design using Figma, establishment of version control infrastructure with GitHub, and implementation of monitoring system prototypes demonstrating drowsiness, distraction, yawning, and smoke detection capabilities.

1. Introduction

1.1 Problem Statement

Road traffic accidents remain one of the leading causes of death and injury worldwide, with driver fatigue and distraction being significant contributing factors. In Sri Lanka's public transportation sector, the lack of real-time driver behavior monitoring systems creates a critical gap in safety management. Current solutions either lack intelligence, require expensive infrastructure, or fail to provide actionable real-time alerts. Public transport passengers lack transparency regarding their safety, and transport authorities struggle to track compliance and incident patterns across their fleet.

1.2 Project Aims

- Develop an intelligent, edge-based driver monitoring system capable of detecting unsafe driver behaviors in real-time
- Provide immediate alerts to drivers and escalate critical incidents to transport authorities
- Measure driving quality and other details by enabling passengers with transparent feedback option through a mobile application
- Empower transport authorities with comprehensive fleet monitoring, analytics, and compliance reporting

1.3 Objectives

- Detect drowsiness using Eye Aspect Ratio (EAR), blink frequency, head pose & yawning detection
- Identify distractions (mobile phone usage) via CNN models
- Implement multi-level alert system (buzzer, voice, authority notifications)
- Integrate GPS-based hazard mapping for accident-prone zones
- Develop passenger transparency mobile application
- Generate automated compliance reports for authorities

1.4 Scope of Progress Report 2

This report is strictly limited to the system design phase. It covers high-level system architecture and component interactions, detailed design specifications supported by UML diagrams, design pattern selection and architectural justification, and documentation of development progress

during the design phase. Implementation is covered through initial prototypes and proof-of-concept demonstrations.

Summary of Chapter 1

This chapter introduces the road safety problem in Sri Lanka's public transport sector, emphasizing accidents caused by driver fatigue and distraction and the lack of real-time monitoring. It explains the aim of SafeDriver as an intelligent, edge-based system that monitors driver behavior, alerts drivers and authorities, and offers transparency to passengers. The chapter defines clear objectives for system architecture, model accuracy, usability, reliability, and real-world validation, and limits this report to the design phase and related prototypes.

2. Summary of the Literature Survey

The literature on driver monitoring systems identifies four main technical approaches: image-based methods using facial features, biological-signal-based methods (EEG, ECG), vehicle-based measures (steering and lane behavior), and hybrid combinations of these. Image-based deep learning models such as 3D CNNs and CNN-LSTM networks have achieved over 90% accuracy for drowsiness detection in controlled environments, while specialized architectures can detect mobile-phone usage and other distractions with accuracy above 95%. These studies demonstrate that computer-vision and deep learning provide a strong technical foundation for real-time detection of risky behaviors, but they are often evaluated under ideal laboratory conditions.

Commercial driver monitoring products from international vendors show that integrated camera-based systems with multi-level alerts and cloud connectivity are technically mature. However, most of these solutions are designed for left-hand-drive vehicles, temperate climates, and high-income markets, leading to limitations when applied directly in Sri Lanka. Key gaps include limited support for Sinhala/Tamil, incomplete specifications for high-humidity tropical environments, and high per-vehicle costs that are difficult to sustain at national scale.

The Sri Lankan road safety context further emphasizes the need for a localized solution. National statistics show thousands of annual road fatalities, with bus accidents strongly linked to fatigue, distraction, and aggressive driving patterns in competitive private operations. The government's 2025 rapid deployment initiative for AI-powered driver monitoring systems confirmed the policy priority but relied primarily on imported commercial systems with limited localization. Studies and government reports highlight additional constraints such as intermittent rural connectivity, right-hand-drive configurations, and economic pressure on transport operators, all of which affect technology adoption.

From this review, several critical research gaps and practical challenges emerge lack of solutions optimized for right-hand-drive buses, insufficient environmental hardening for tropical climates, limited multilingual and culturally adapted user interfaces, and high-cost barriers for large-scale deployment. The SafeDriver system is positioned to address these gaps through locally developed, Raspberry-Pi-based hardware, TensorFlow Lite models optimized for edge deployment, offline-capable GPS hazard mapping, and multilingual interfaces for drivers, passengers, and authorities.

Summary of Chapter 2

This chapter reviews research and commercial solutions for driver monitoring, covering image-based, bio-signal, vehicle-based, and hybrid approaches along with state-of-the-art deep learning models. It highlights that existing systems are accurate but mostly evaluated in ideal conditions and are poorly adapted to Sri Lanka's right-hand-drive vehicles, tropical climate, language needs, and cost constraints. The chapter concludes that these gaps justify a localized, low-cost, Raspberry-Pi-based, multilingual SafeDriver system with edge AI and offline-capable features tailored to Sri Lankan public transport.

3. Methodology

3.1 Design Approach

The system design follows a model-driven development approach with iterative refinement based on stakeholder feedback. UML modeling techniques provide formal specification of system structure, behavior, and interactions. Design patterns are intentionally selected and mapped to specific system components to ensure maintainability, extensibility, and adherence to SOLID principles.

3.2 Proposed System Architecture

The SafeDriver system employs a four-tier hybrid edge-cloud architecture:

3.2.1 Edge Device Layer

Raspberry Pi 4 with Pi Camera Module, GPS module, Fingerprint scanner and audio alert system. Runs Python-based driver monitoring subsystem with TensorFlow Lite inference engine. Performs real-time computer vision processing for behavioral detection.

3.2.2 Processing Layer

Core monitoring system components: FacialLandmarkDetector, DrowsinessDetector, DistractionDetector, AlertSystem, GPSModule, and HazardZoneManager. Implements alert escalation logic with severity levels and notification routing.

3.2.3 Cloud Infrastructure Layer

Firebase Realtime Database for event storage and synchronization, Firebase Cloud Functions for backend logic, and Google Cloud Platform infrastructure for scalability. Provides data persistence, analytics aggregation, and third-party integrations.

3.2.4 Application Layer

Web-based Authority Dashboard (NextJS with real-time updates), Passenger Mobile Application (Flutter for iOS and Android), and Driver Monitoring Interface (Fast API). Each provides role-specific views and interactions.

3.3 Design Patterns Employed

Three primary design patterns selected for specific architectural roles:

3.3.1 Observer Pattern

Applied to alert escalation system. AlertSystem acts as subject; Web Dashboard. When behavioral anomalies exceed thresholds, observers are notified asynchronously, ensuring loose coupling.

3.3.2 Singleton Pattern

Applied to DriverMonitoringSystem and FirebaseConnector. Ensures single, globally accessible instance managing device state and cloud communication, preventing resource conflicts.

3.3.3 Strategy Pattern

Applied to alert notification strategies. Different strategies (SMS, Cloud Notification, Voice Alert, Emergency Call) implement common interface; AlertSystem selects strategy based on severity level and recipient role.

3.4 Data Flow and Integration

System follows event-driven data flow: camera captures frames → face detection → behavioral analysis → alert generation (if thresholds exceeded) → multi-channel notification dispatch → cloud synchronization → analytics aggregation. Offline buffering ensures resilience during connectivity loss, with automatic sync upon reconnection. Parallelly detect hazard zones as sub process of the system.

Summary of Chapter 3

This chapter details a model-driven, iterative design methodology for SafeDriver, combining UML-based specification, a four-tier hybrid edge–cloud architecture, and carefully selected design patterns to ensure maintainability and scalability. It explains how data flows from in-vehicle detection through event-driven alerts and cloud synchronization to user-facing applications, using patterns such as Observer, Singleton and Strategy to support flexible integration and robust real-time behavior.

4. UML Diagrams

4.1 Use Case Diagram

Figure 1 - Use case diagram

4.2 System Architecture Diagram

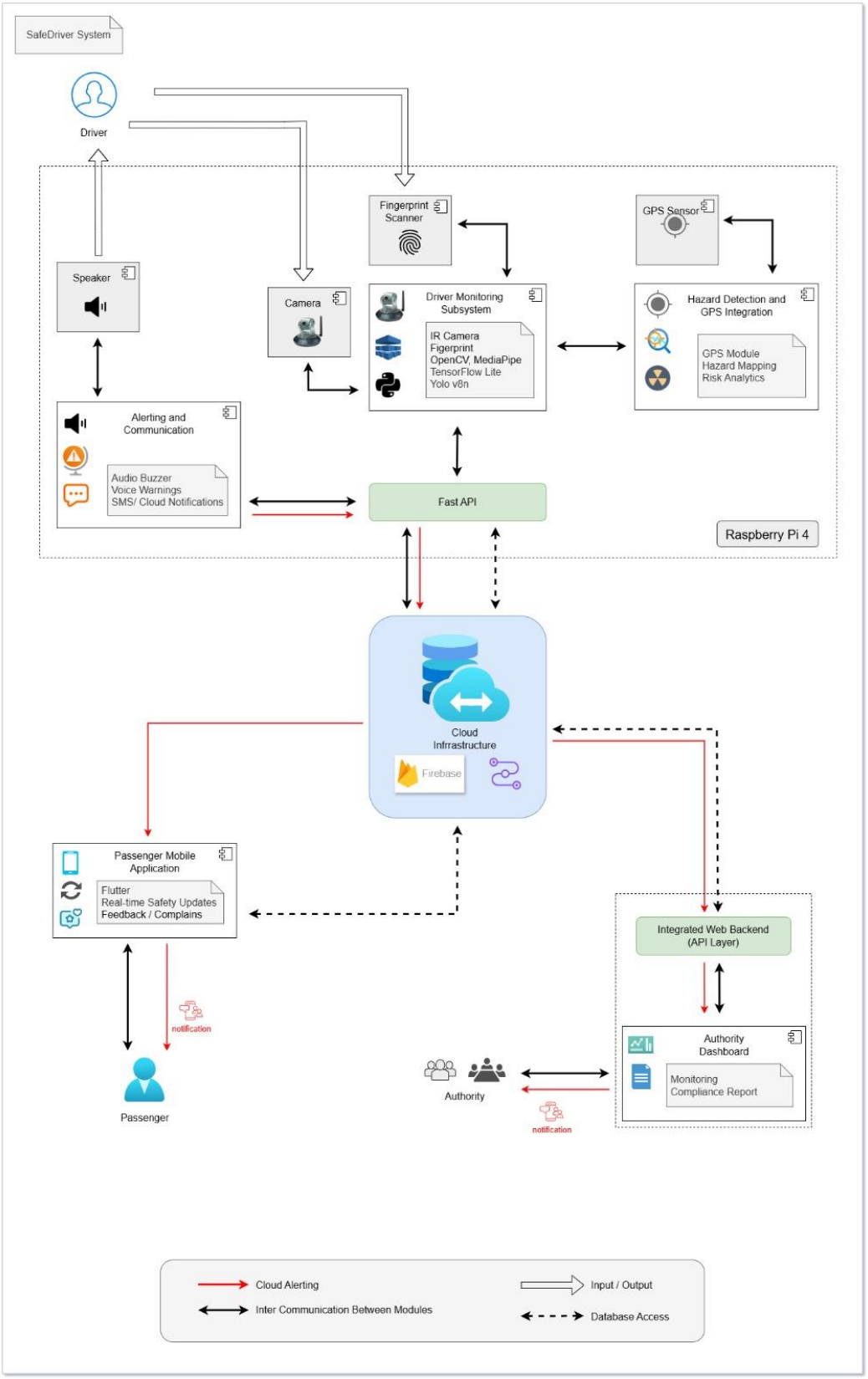


Figure 2 - System architecture diagram

4.3 Class Diagram

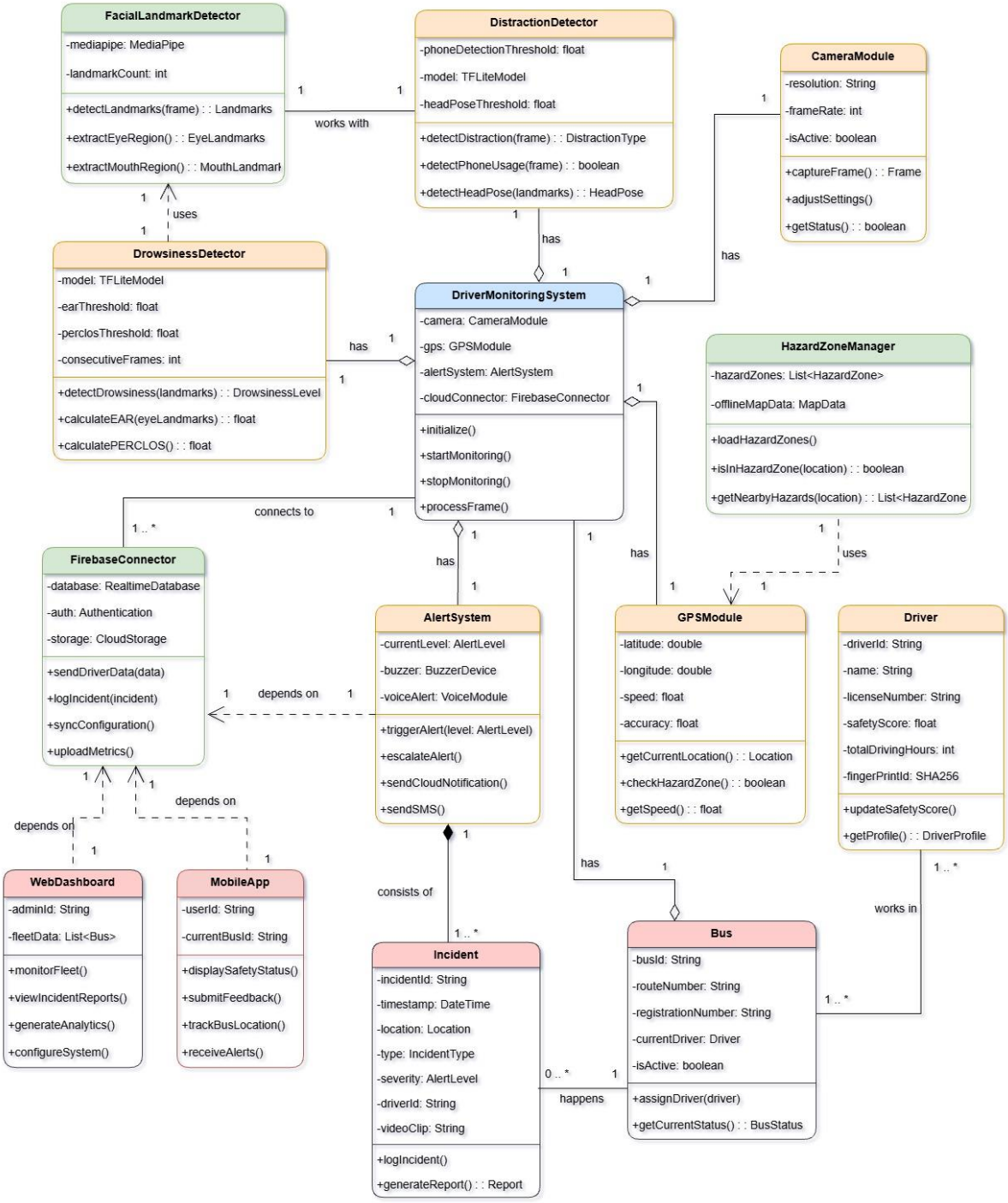


Figure 3 - Class Diagram

4.4 Sequence Diagram

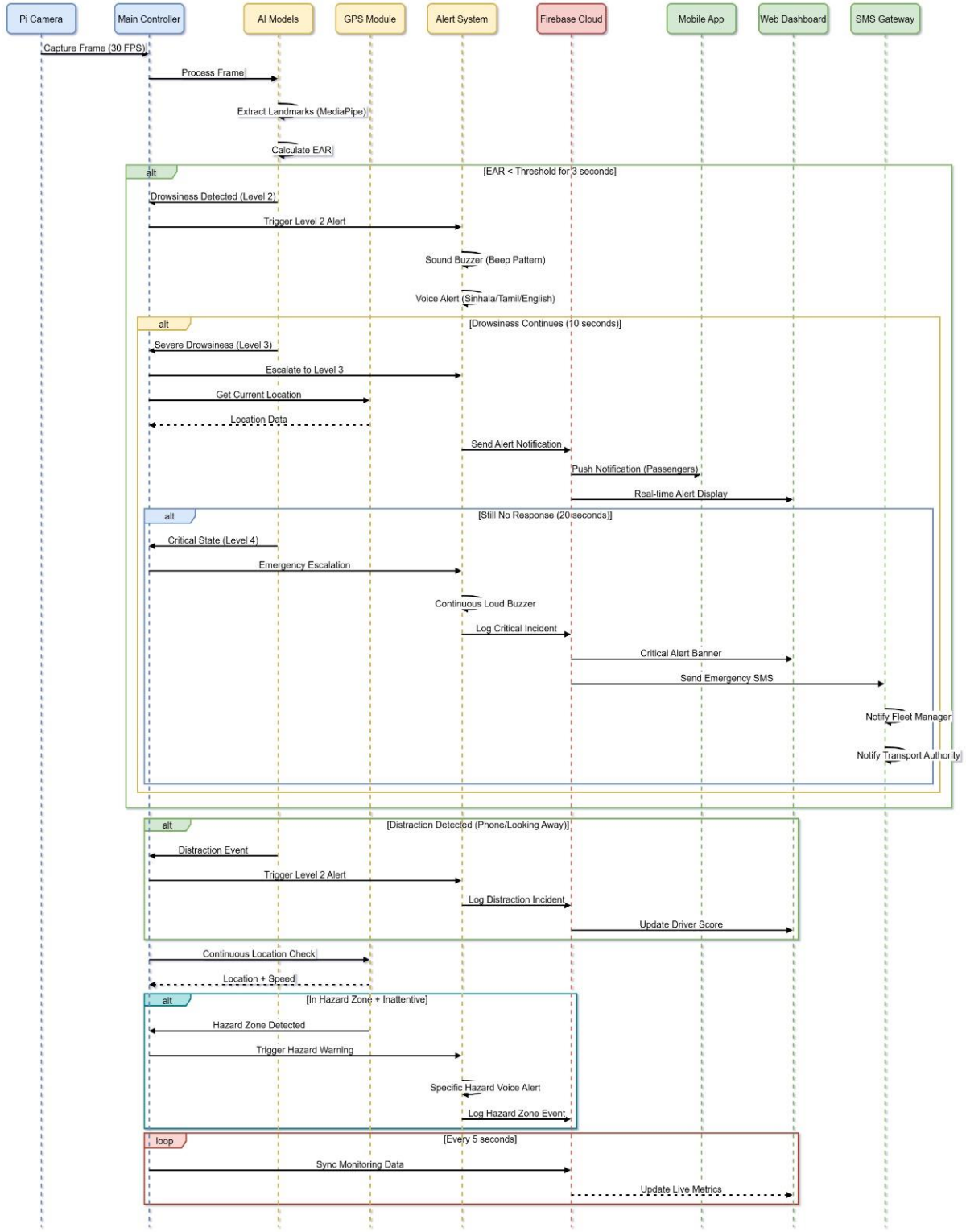


Figure 4 - Sequence Diagram

4.5 Activity Diagram

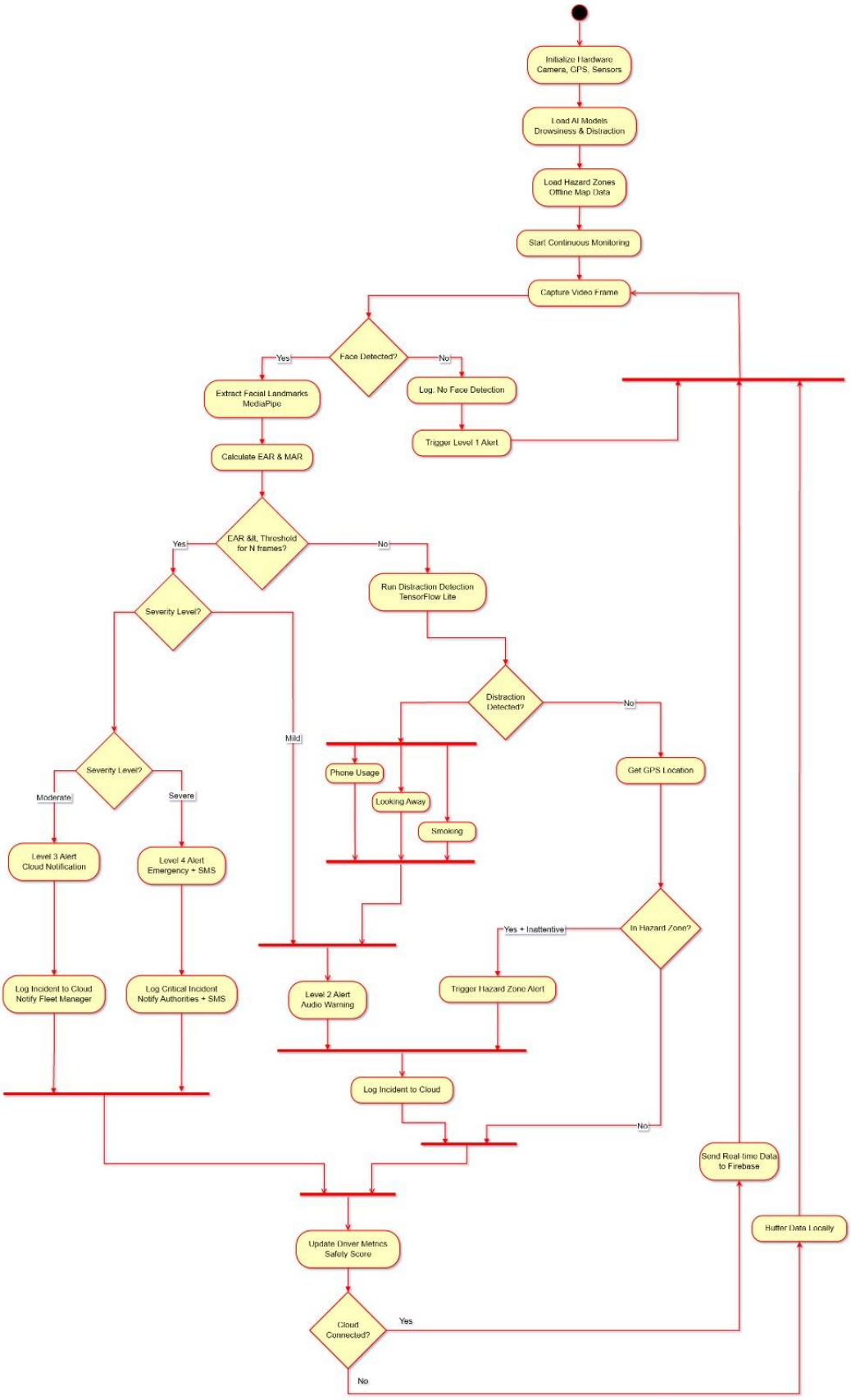


Figure 5 - Activity Diagram

4.6 Raspberry Model Diagram

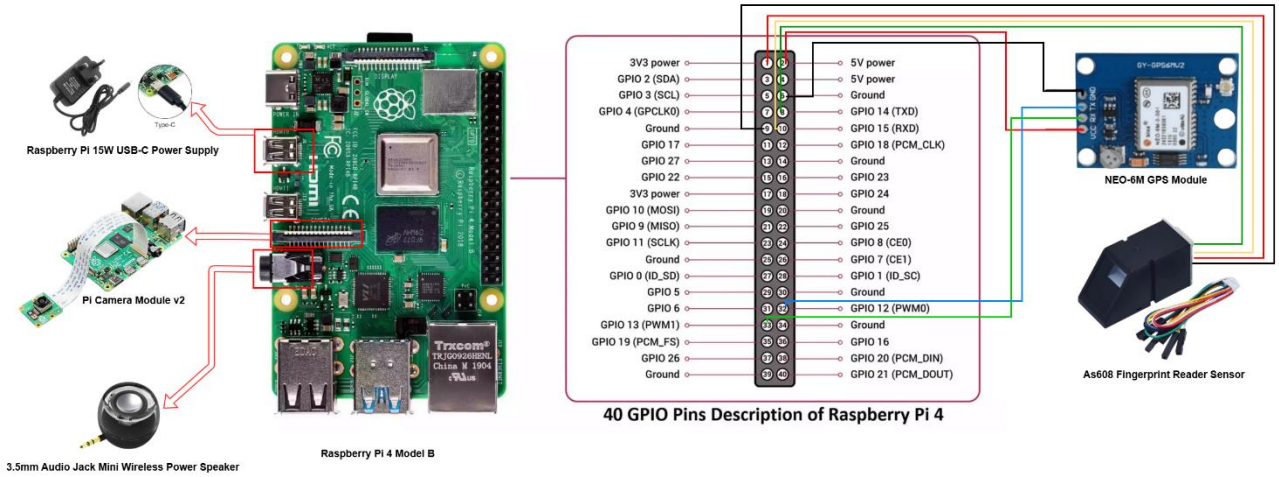


Figure 6 - Raspberry Model Diagram

5. Implementation

5.1 Monitoring System

The embedded monitoring system has been implemented as a Python application with Fast API running on Raspberry Pi 4. The prototype successfully demonstrates:

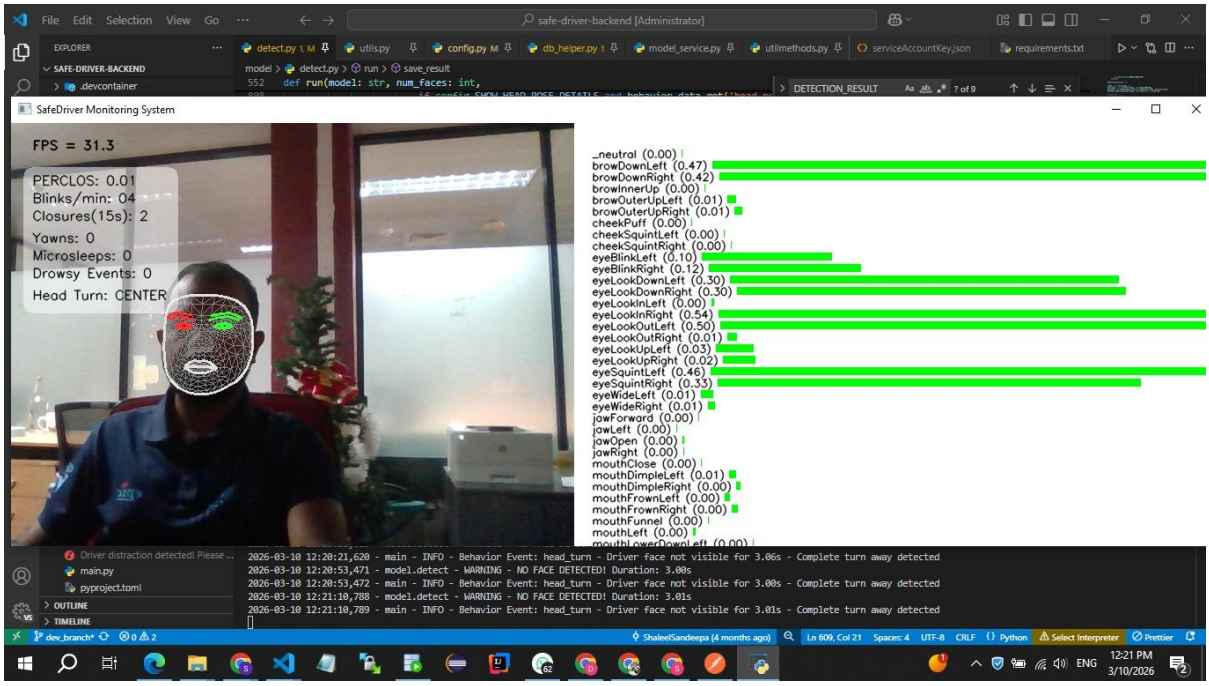
- Real-time facial landmark detection using MediaPipe and OpenCV
- Drowsiness detection through Eye Aspect Ratio (EAR) analysis achieving >80% accuracy
- Yawning detection through Mouth Aspect Ratio (MAR) analysis achieving >80% accuracy
- Detect other behaviors including microsleep, head pose, driver distraction (Fully head turn)
- Distraction detection identifying phone usage, smoking, drinking water while driving, earbuds.
- Sub-500ms alert generation and multi-channel notification dispatch

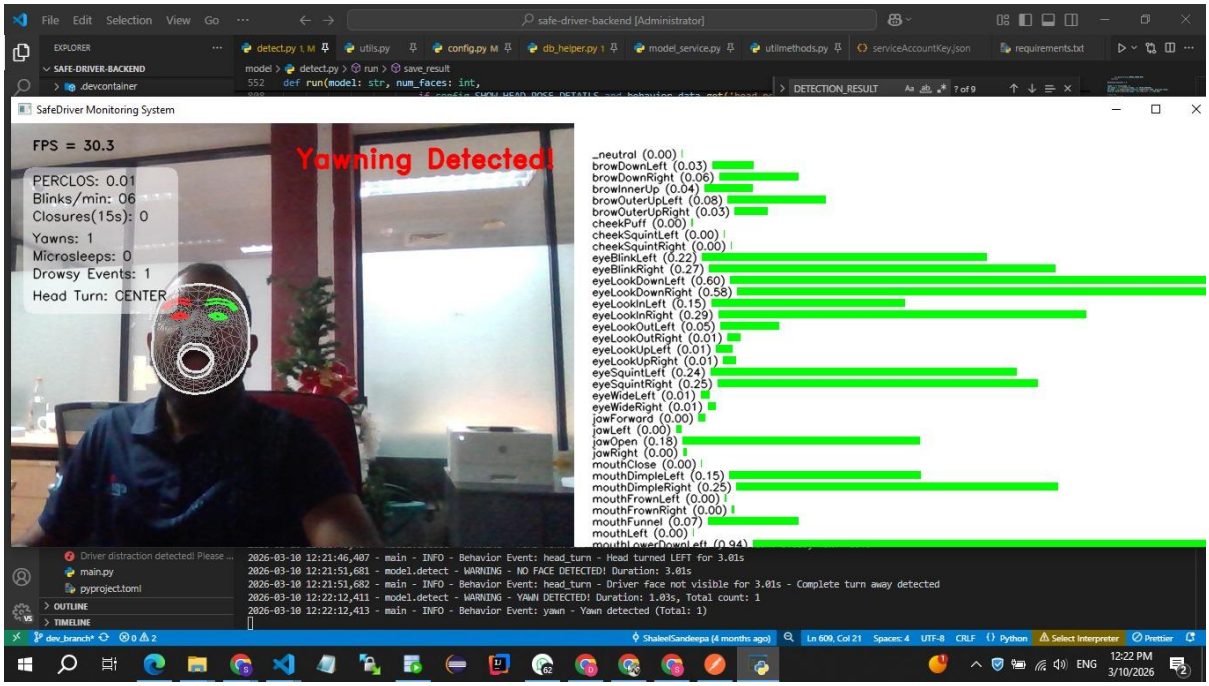
Key metrics from current implementation:

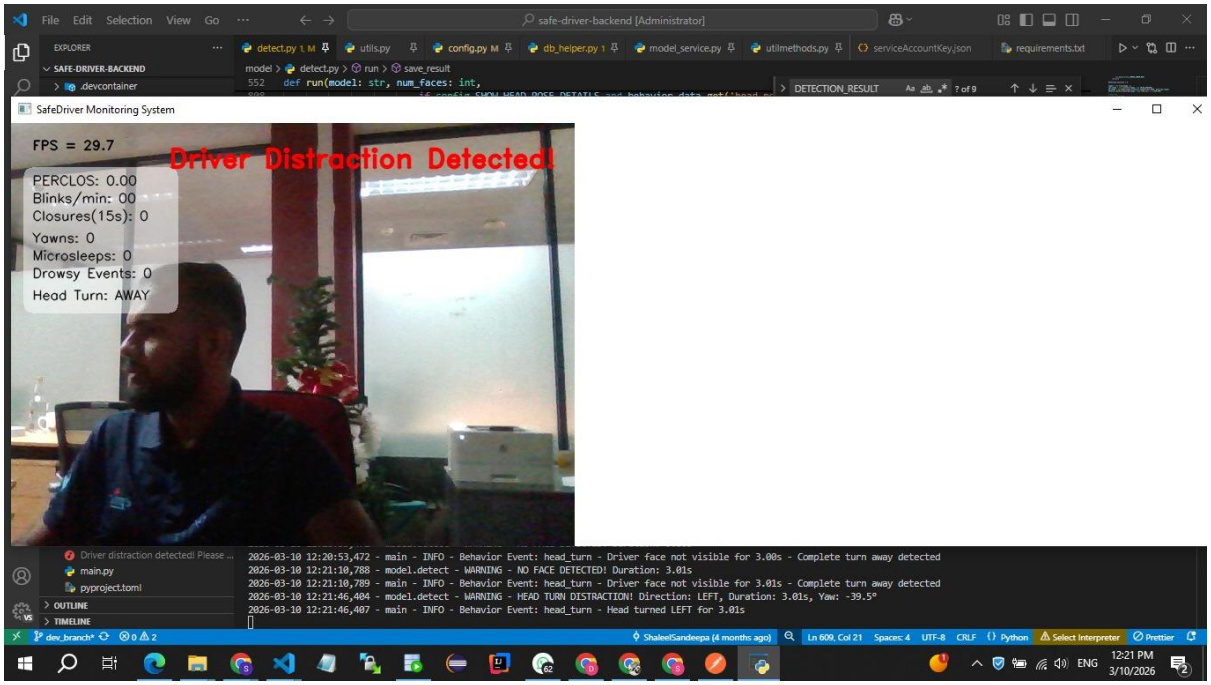
FPS (Frames Per Second) averaging 25-31 fps, PERCLOS (Percentage of Eyelid Closure) calculation for drowsiness, yawning and microsleep counts for all detections displayed in real-time monitoring interface.

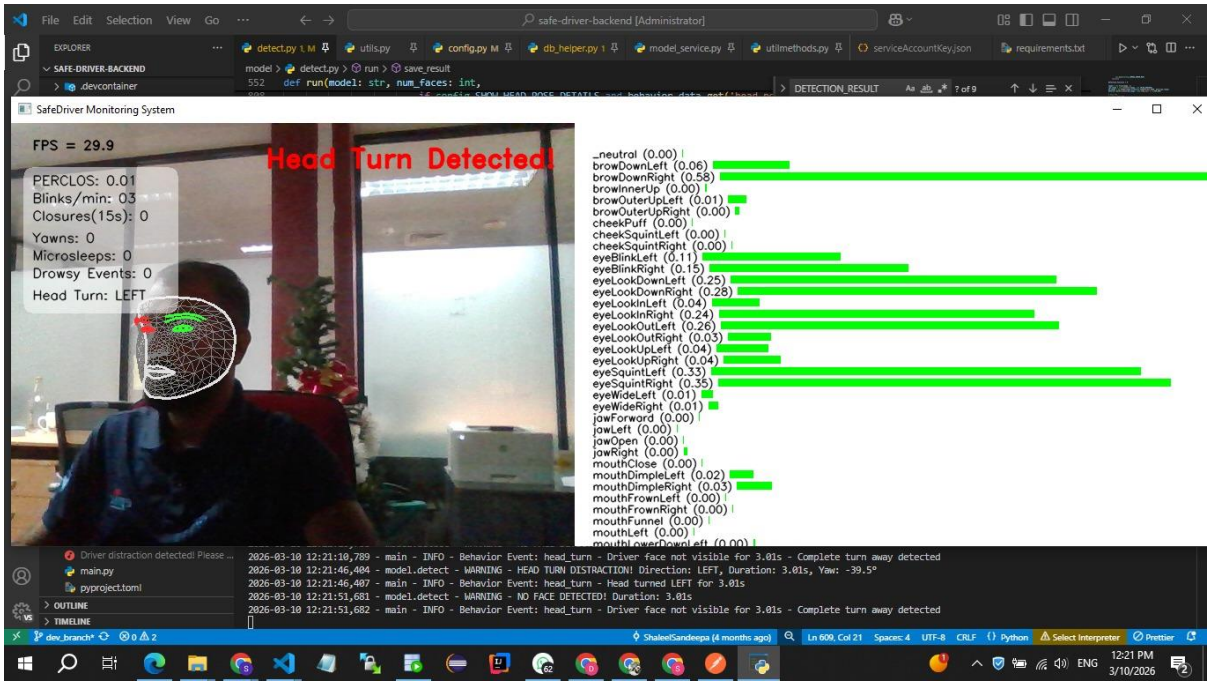
5.1.1 Technical Stack

- Language: Python 3.10.9
- API – Fast API
- Vision Libraries: OpenCV, MediaPipe, TensorFlow Lite, YOLOv8
- Hardware: Raspberry Pi 4 (4GB RAM), Pi Camera Module v2, As608 Fingerprint Reader Sensor, GPS Module (NEO-6M), Audio Speaker
- Cloud Integration: Firebase Python SDK for data synchronization


SafeDriver Monitoring System
FPS = 31.3
PERCLOS: 0.01
Blinks/min: 04
Closures(15s): 2
Yawns: 0
Microsleeps: 0
Drowsy Events: 0
Head Turn: CENTER
_neutral (0.00)
browDownLeft (0.47)
browDownRight (0.42)
browInnerUp (0.00)
browOuterUpLeft (0.01)
browOuterUpRight (0.01)
cheekPuff (0.00)
cheekSquintLeft (0.00)
cheekSquintRight (0.00)
eyeBlinkLeft (0.10)
eyeBlinkRight (0.12)
eyeLookDownLeft (0.30)
eyeLookDownRight (0.30)
eyeLookInLeft (0.00)
eyeLookInRight (0.54)
eyeLookOutLeft (0.50)
eyeLookOutRight (0.01)
eyeLookUpLeft (0.03)
eyeLookUpRight (0.02)
eyeSquintLeft (0.46)
eyeSquintRight (0.33)
eyeWideLeft (0.01)
eyeWideRight (0.01)
jawForward (0.00)
jawLeft (0.00)
jawOpen (0.00)
jawRight (0.00)
mouthClose (0.00)
mouthDimpleLeft (0.01)
mouthDimpleRight (0.00)
mouthFrownLeft (0.00)
mouthFrownRight (0.00)
mouthFunnel (0.00)
mouthLeft (0.00)
2026-03-10 12:20:21,620 - main - INFO - Behavior Event: head_turn - Driver face not visible for 3.06s - Complete turn away detected
2026-03-10 12:20:53,471 - model.detect - WARNING - NO FACE DETECTED! Duration: 3.00s
2026-03-10 12:20:53,472 - main - INFO - Behavior Event: head_turn - Driver face not visible for 3.00s - Complete turn away detected
2026-03-10 12:21:10,788 - model.detect - WARNING - NO FACE DETECTED! Duration: 3.01s
2026-03-10 12:21:10,789 - main - INFO - Behavior Event: head_turn - Driver face not visible for 3.01s - Complete turn away detected


SafeDriver Monitoring System
FPS = 30.3
Yawning Detected!
PERCLOS: 0.01
Blinks/min: 06
Closures(15s): 0
Yawns: 1
Microsleeps: 0
Drowsy Events: 1
Head Turn: CENTER
_neutral (0.00)
browDownLeft (0.03)
browDownRight (0.06)
browInnerUp (0.04)
browOuterUpLeft (0.08)
browOuterUpRight (0.03)
cheekPuff (0.00)
cheekSquintLeft (0.00)
cheekSquintRight (0.00)
eyeBlinkLeft (0.22)
eyeBlinkRight (0.27)
eyeLookDownLeft (0.60)
eyeLookDownRight (0.58)
eyeLookInLeft (0.15)
eyeLookInRight (0.29)
eyeLookOutLeft (0.05)
eyeLookOutRight (0.01)
eyeLookUpLeft (0.01)
eyeLookUpRight (0.01)
eyeSquintLeft (0.24)
eyeSquintRight (0.25)
eyeWideLeft (0.01)
eyeWideRight (0.01)
jawForward (0.00)
jawLeft (0.00)
jawOpen (0.18)
jawRight (0.00)
mouthClose (0.00)
mouthDimpleLeft (0.15)
mouthDimpleRight (0.25)
mouthFrownLeft (0.00)
mouthFrownRight (0.00)
mouthFunnel (0.07)
mouthLeft (0.00)
2026-03-10 12:21:46,407 - main - INFO - Behavior Event: head_turn - Head turned LEFT for 3.01s
2026-03-10 12:21:51,681 - model.detect - WARNING - NO FACE DETECTED! Duration: 3.01s
2026-03-10 12:21:51,682 - main - INFO - Behavior Event: head_turn - Driver face not visible for 3.01s - Complete turn away detected
2026-03-10 12:22:12,411 - model.detect - WARNING - YAWN DETECTED! Duration: 1.03s, Total count: 1
2026-03-10 12:22:12,413 - main - INFO - Behavior Event: yawn - Yawn detected (Total: 1)


SafeDriver Monitoring System
FPS = 29.7
Driver Distraction Detected!
PERCLOS: 0.00
Blinks/min: 00
Closures(15s): 0
Yawns: 0
Microsleeps: 0
Drowsy Events: 0
Head Turn: AWAY
2026-03-10 12:20:53,472 - main - INFO - Behavior Event: head_turn - Driver face not visible for 3.00s - Complete turn away detected
2026-03-10 12:21:10,788 - model.detect - WARNING - NO FACE DETECTED! Duration: 3.01s
2026-03-10 12:21:10,789 - main - INFO - Behavior Event: head_turn - Driver face not visible for 3.01s - Complete turn away detected
2026-03-10 12:21:46,404 - model.detect - WARNING - HEAD TURN DISTRACTION! Direction: LEFT, Duration: 3.01s, Yaw: -39.5°
2026-03-10 12:21:46,407 - main - INFO - Behavior Event: head_turn - Head turned LEFT for 3.01s


SafeDriver Monitoring System
FPS = 29.9
Head Turn Detected!
PERCLOS: 0.01
Blinks/min: 03
Closures(15s): 0
Yawns: 0
Microsleeps: 0
Drowsy Events: 0
Head Turn: LEFT
_neutral (0.00)
browDownLeft (0.06)
browDownRight (0.58)
browInnerUp (0.00)
browOuterUpLeft (0.01)
browOuterUpRight (0.00)
cheekPuff (0.00)
cheekSquintLeft (0.00)
cheekSquintRight (0.00)
eyeBlinkLeft (0.11)
eyeBlinkRight (0.15)
eyeLookDownLeft (0.25)
eyeLookDownRight (0.28)
eyeLookInLeft (0.04)
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eyeLookOutLeft (0.26)
eyeLookOutRight (0.03)
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eyeSquintLeft (0.33)
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mouthFrownRight (0.00)
mouthFunnel (0.00)
mouthLeft (0.00)
2026-03-10 12:21:10,789 - main - INFO - Behavior Event: head_turn - Driver face not visible for 3.01s - Complete turn away detected
2026-03-10 12:21:46,404 - model.detect - WARNING - HEAD TURN DISTRACTION! Direction: LEFT, Duration: 3.01s, Yaw: -39.5°
2026-03-10 12:21:46,407 - main - INFO - Behavior Event: head_turn - Head turned LEFT for 3.01s
2026-03-10 12:21:51,681 - model.detect - WARNING - NO FACE DETECTED! Duration: 3.01s
2026-03-10 12:21:51,682 - main - INFO - Behavior Event: head_turn - Driver face not visible for 3.01s - Complete turn away detected

5.2 Authority Dashboard

A comprehensive web-based dashboard has been designed and partially implemented, providing transport authorities with fleet-wide visibility:

5.2.1 Core Dashboard Features

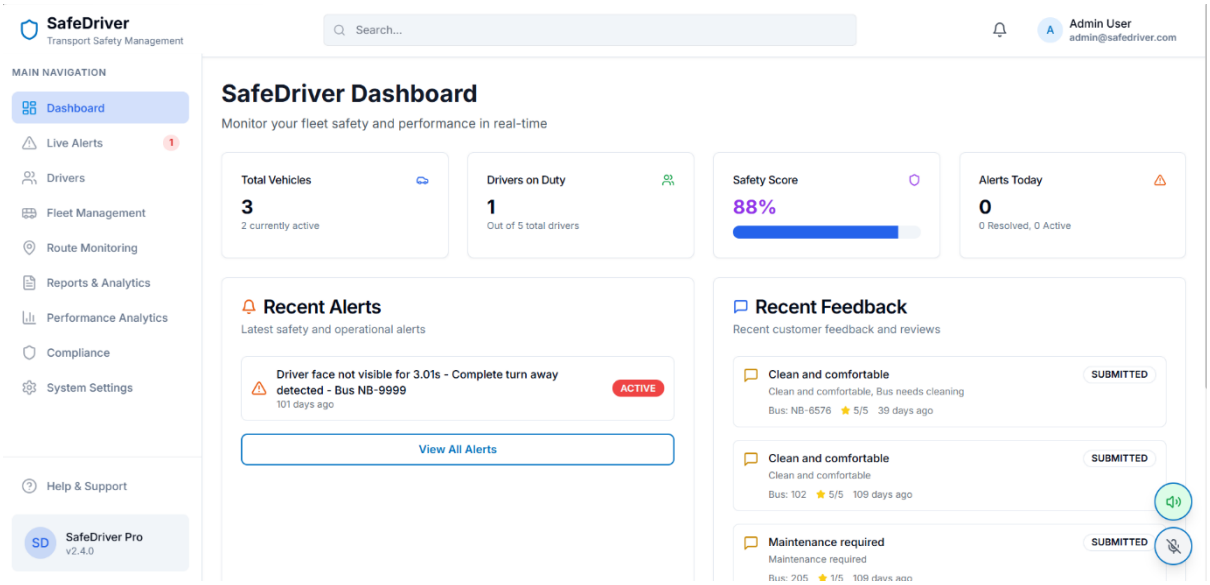
- Real-time KPI display: Total Vehicles, Drivers on Duty, Overall Safety Score, Active Alerts
- Live Alerts section with status filtering (All, Active, Acknowledged, Resolved)
- Recent Feedback display showing passenger comments with priority tags
- Driver Management interface for profile review and performance tracking

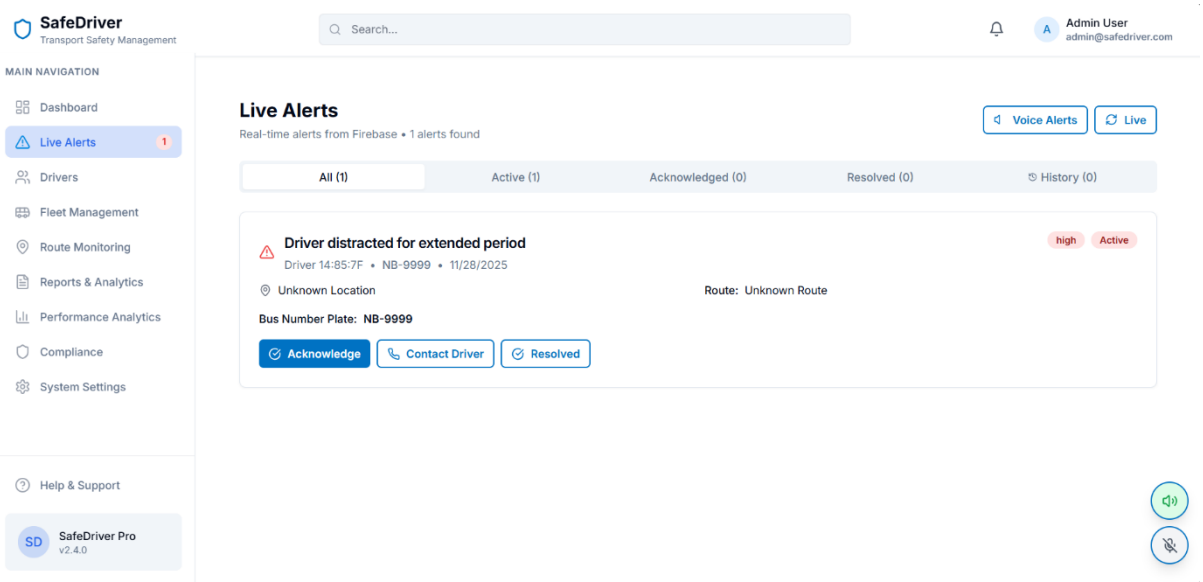
5.2.2 Additional Modules

- Fleet Management System: Vehicle inventory, live tracking, analytics
- Feedback Management: Customer submissions with rating aggregation
- Compliance Reporting: Automated incident reports, trend analysis
- System Settings: Configuration management, user administration

5.2.3 Technical Stack

- Framework: NextJS (Frontend and Backend)
- Database: Firebase Realtime Database with Firestore for complex queries
- Real-time Updates: Firebase WebSocket integration

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Dashboard
Live Alerts
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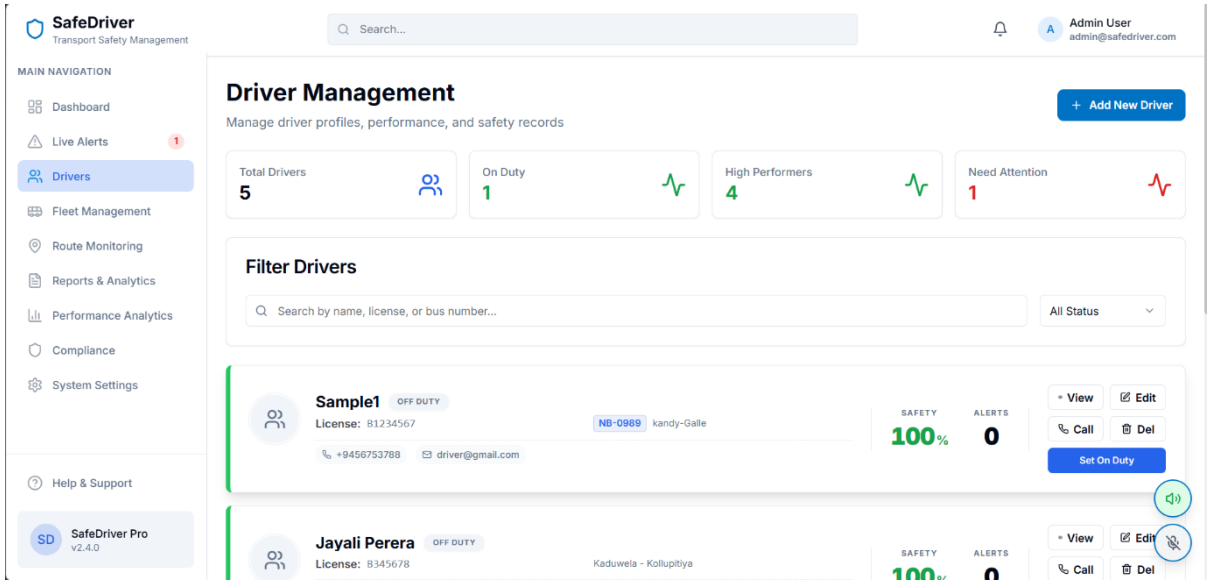
Fleet Management
Route Monitoring
Reports & Analytics
Performance Analytics
Compliance
System Settings
Help & Support
SD
SafeDriver Pro
v2.4.0
Live Alerts
Real-time alerts from Firebase • 1 alerts found
Voice Alerts
Live
All (1)
Active (1)
Acknowledged (0)
Resolved (0)
History (0)
Driver distracted for extended period
Driver 14:85:7F • NB-9999 • 11/28/2025
high
Active
Unknown Location
Route: Unknown Route
Bus Number Plate: NB-9999
Acknowledge
Contact Driver
Resolved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System Settings
Help & Support
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Driver Management
Manage driver profiles, performance, and safety records
Add New Driver
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On Duty
1
High Performers
4
Need Attention
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Filter Drivers
Search by name, license, or bus number...
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driver@gmail.com
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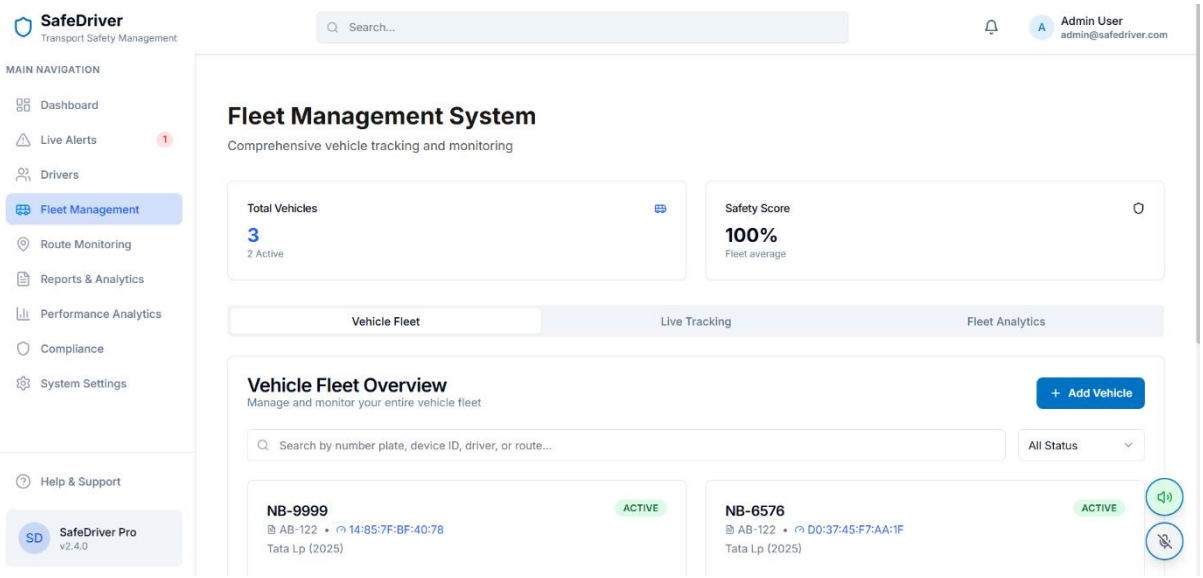
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Compliance
System Settings
Help & Support
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v2.4.0
Fleet Management System
Comprehensive vehicle tracking and monitoring
Total Vehicles
3
2 Active
Safety Score
100%
Fleet average
Vehicle Fleet
Live Tracking
Fleet Analytics
Vehicle Fleet Overview
Manage and monitor your entire vehicle fleet
Add Vehicle
Search by number plate, device ID, driver, or route...
All Status
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ACTIVE
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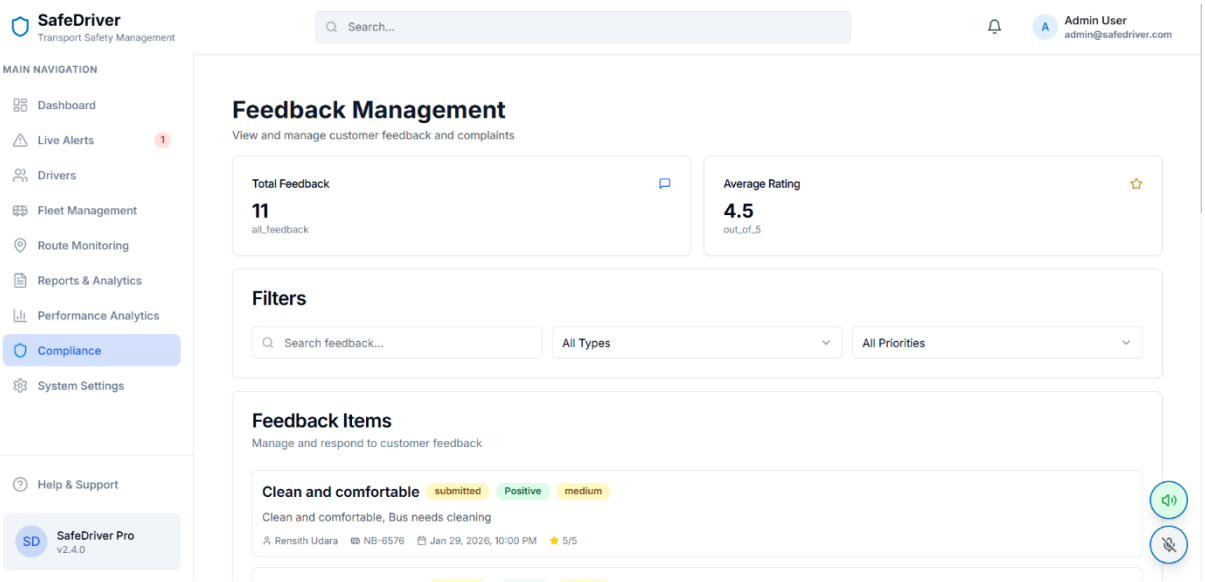
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Fleet Management
Route Monitoring
Reports & Analytics
Performance Analytics
Compliance
System Settings
Help & Support
SafeDriver Pro
v2.4.0
Feedback Management
View and manage customer feedback and complaints
Total Feedback
11
all_feedback
Average Rating
4.5
out_of_5
Filters
Search feedback...
All Types
All Priorities
Feedback Items
Manage and respond to customer feedback
Clean and comfortable
submitted
Positive
medium
Clean and comfortable, Bus needs cleaning
Rensith Udara
NB-6576
Jan 29, 2026, 10:00 PM
5/5

5.3 Passenger Mobile App

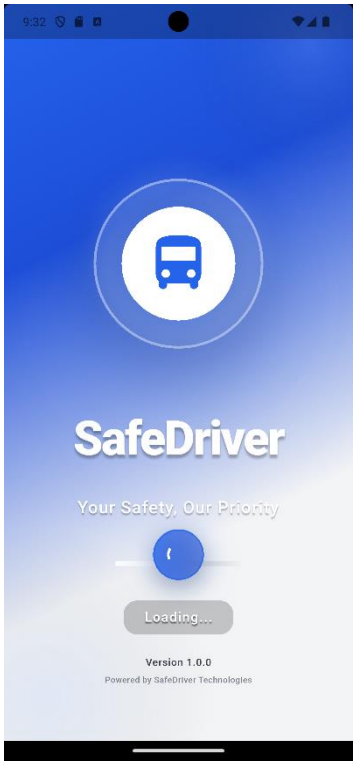
The mobile application provides passengers with transparency and safety features through an intuitive, multilingual interface:

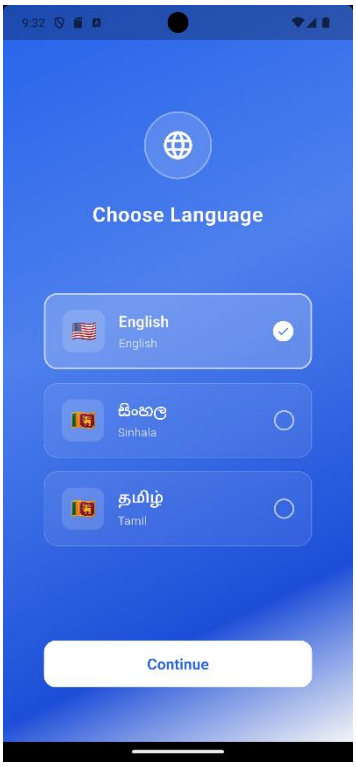
5.3.1 Key Features

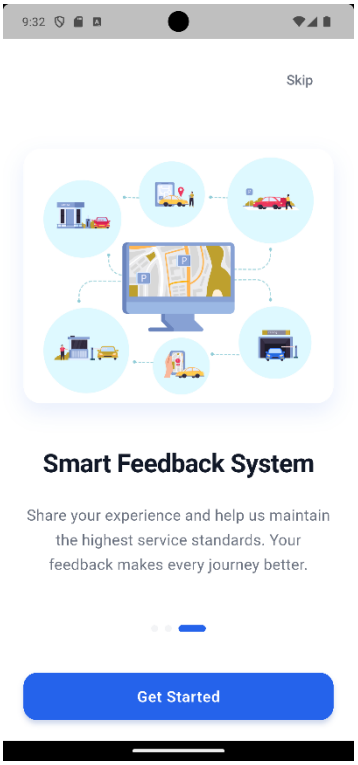
- User Onboarding: Language selection (English, Sinhala, Tamil), account creation, login
- Real-time Tracking: Bus location, route display, ETA estimation
- Driver Information: Verified driver profiles with safety ratings
- Smart Feedback System: Separate bus and driver feedback with multi-option quick selection
- Emergency Features: Quick access to emergency contacts, SOS alerts
- QR Code Scanning: Board identification and journey tracking
- Help & Support: call support, FAQs, travel statistics

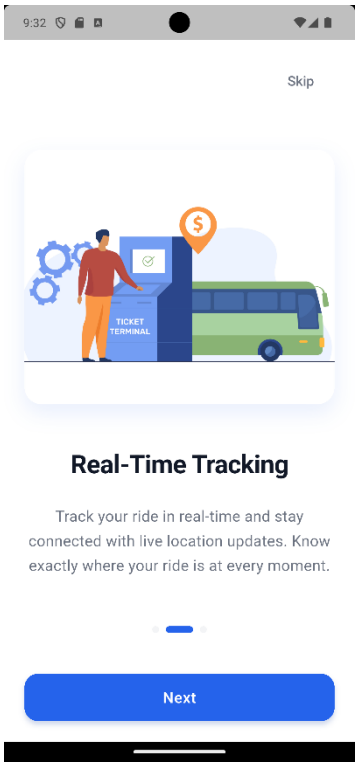
5.3.2 Technical Stack

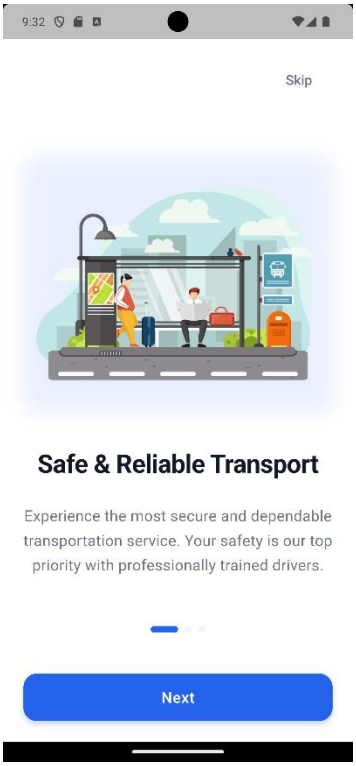
- Framework: Flutter 3.35.1
- Platforms: iOS 13+, Android 8+
- Backend: Firebase Authentication, Firestore, Cloud Functions
- Maps Integration: Google Maps API for real-time tracking
- Localization: Multi-language support via i18n library

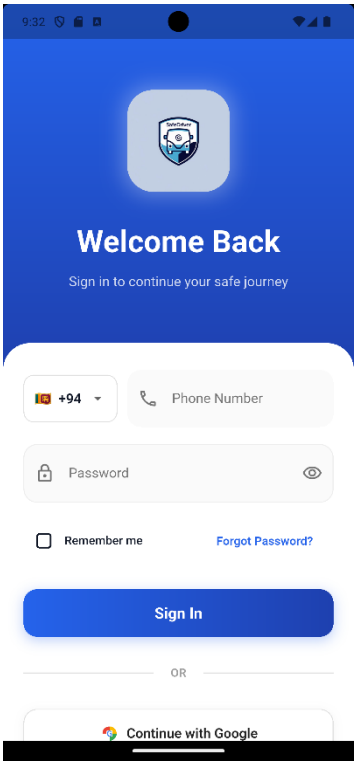

SafeDriver
Your Safety, Our Priority
Loading...
Version 1.0.0
Powered by SafeDriver Technologies

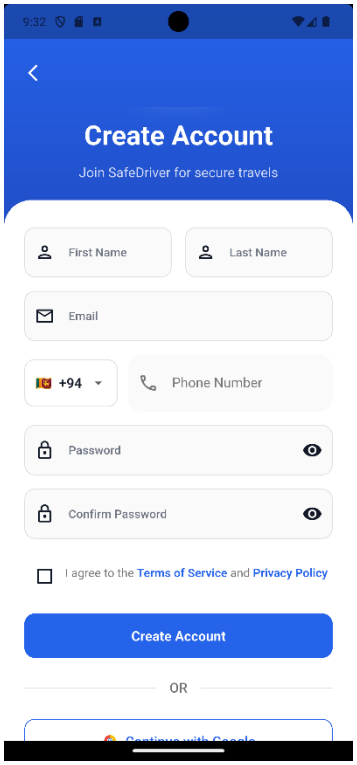

Choose Language
English
English
සිංහල
Sinhala
தமிழ்
Tamil
Continue

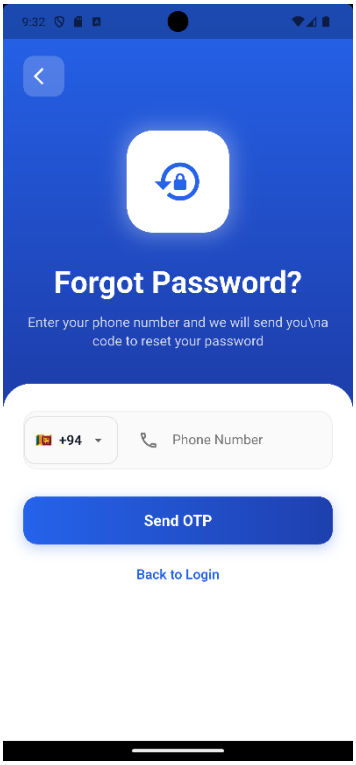

Skip
Smart Feedback System
Share your experience and help us maintain the highest service standards. Your feedback makes every journey better.
Get Started

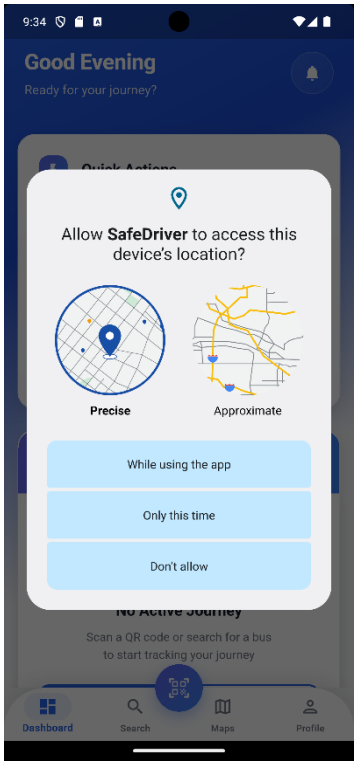

Skip
TICKET TERMINAL
Real-Time Tracking
Track your ride in real-time and stay connected with live location updates. Know exactly where your ride is at every moment.
Next

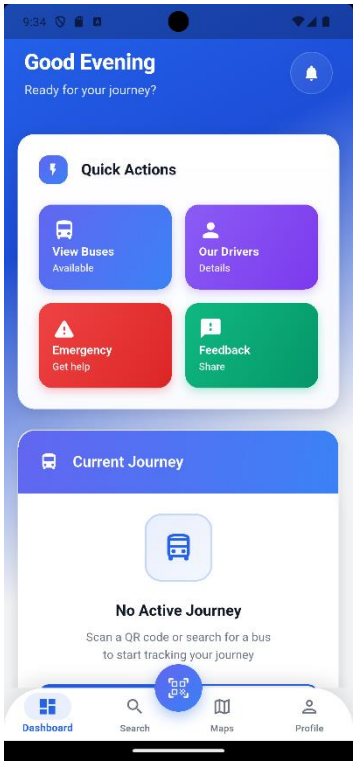

Skip
Safe & Reliable Transport
Experience the most secure and dependable transportation service. Your safety is our top priority with professionally trained drivers.
Next

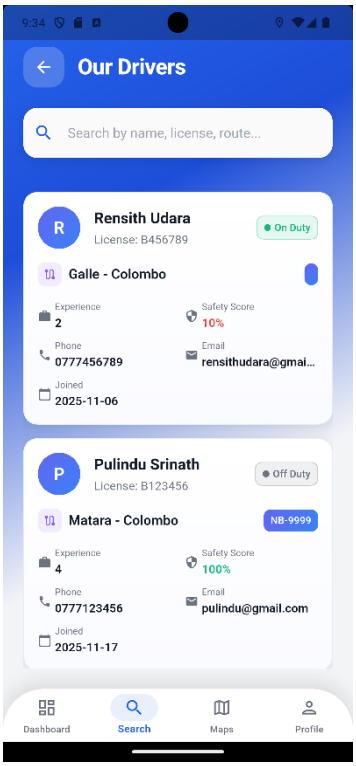

Welcome Back
Sign in to continue your safe journey
+94
Phone Number
Password
Remember me
Forgot Password?
Sign In
OR
Continue with Google

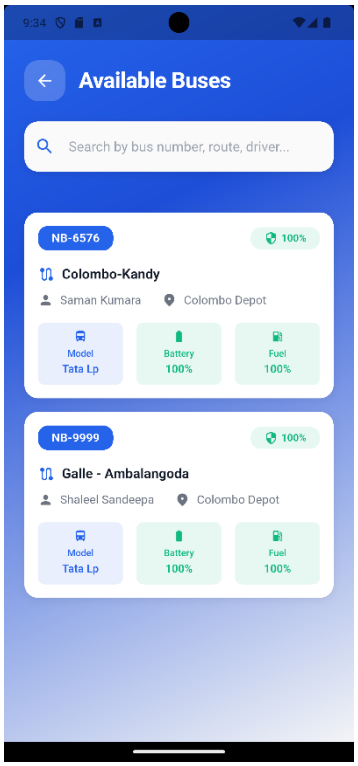

Create Account
Join SafeDriver for secure travels
First Name
Last Name
Email
+94
Phone Number
Password
Confirm Password
I agree to the Terms of Service and Privacy Policy
Create Account
OR

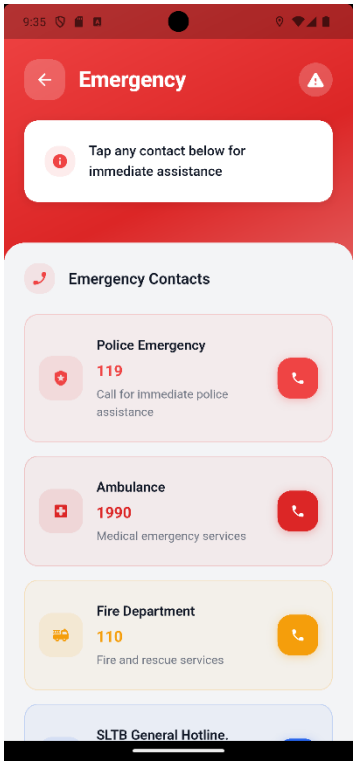

Forgot Password?
Enter your phone number and we will send you\na code to reset your password
+94
Phone Number
Send OTP
Back to Login

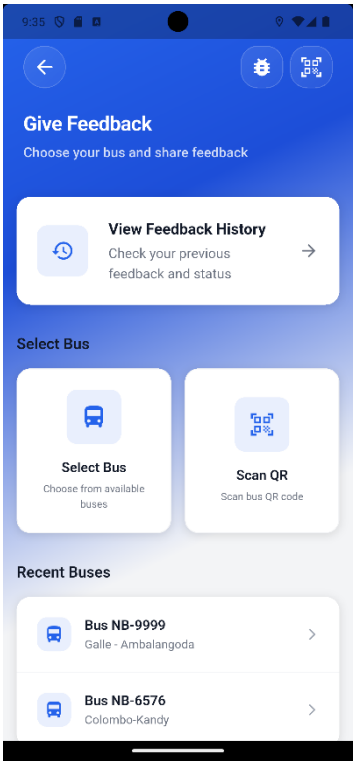

Good Evening
Ready for your journey?
Allow SafeDriver to access this device's location?
Precise
Approximate
While using the app
Only this time
Don't allow
Scan a QR code or search for a bus to start tracking your journey
Dashboard
Search
Maps
Profile

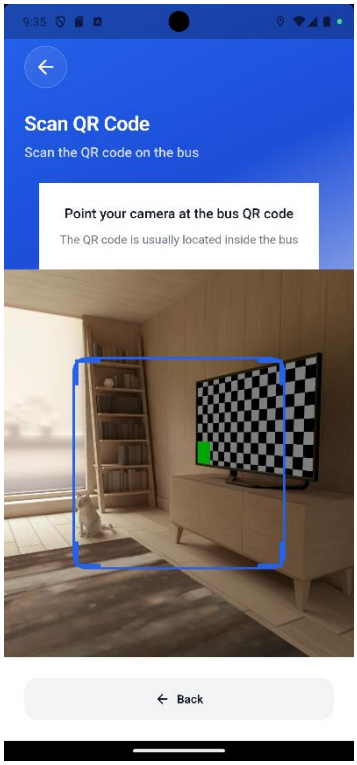

Good Evening
Ready for your journey?
Quick Actions
View Buses
Available
Our Drivers
Details
Emergency
Get help
Feedback
Share
Current Journey
No Active Journey
Scan a QR code or search for a bus to start tracking your journey
Dashboard
Search
Maps
Profile

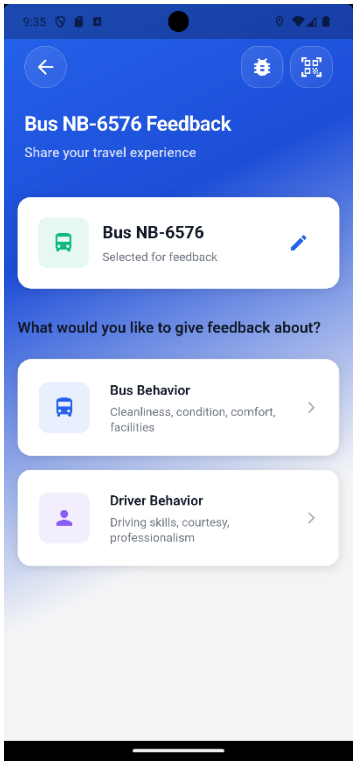

Our Drivers
Search by name, license, route...
Rensith Udara
License: B456789
On Duty
Galle - Colombo
Experience
2
Safety Score
10%
Phone
0777456789
Email
rensithudara@gmai...
Joined
2025-11-06
Pulindu Srinath
License: B123456
Off Duty
Matara - Colombo
NB-9999
Experience
4
Safety Score
100%
Phone
0777123456
Email
pulindu@gmail.com
Joined
2025-11-17
Dashboard
Search
Maps
Profile

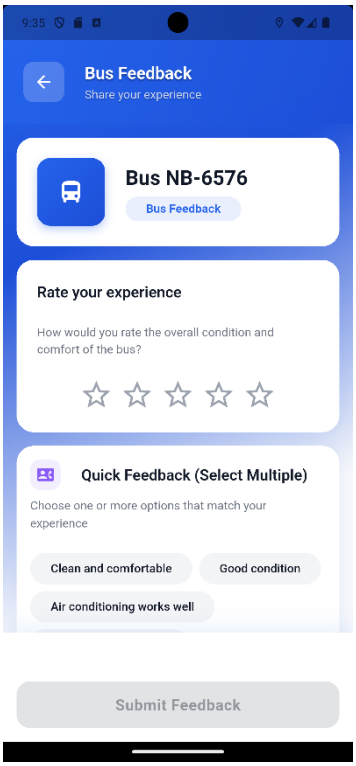

Available Buses
Search by bus number, route, driver...
NB-6576
100%
Colombo-Kandy
Saman Kumara
Colombo Depot
Model
Tata Lp
Battery
100%
Fuel
100%
NB-9999
100%
Galle - Ambalangoda
Shaleel Sandeepa
Colombo Depot
Model
Tata Lp
Battery
100%
Fuel
100%

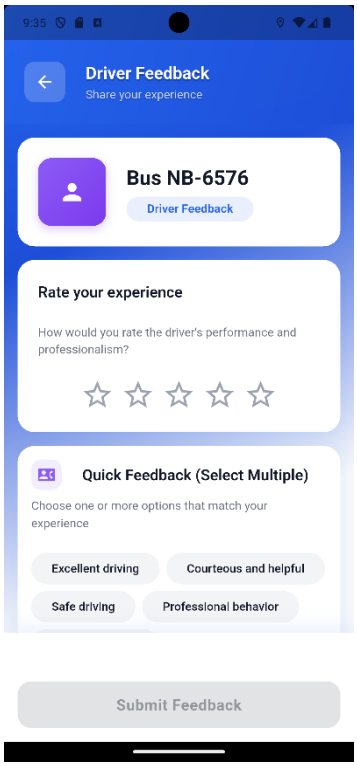

Emergency
Tap any contact below for immediate assistance
Emergency Contacts
Police Emergency
119
Call for immediate police assistance
Ambulance
1990
Medical emergency services
Fire Department
110
Fire and rescue services
SLTB General Hotline.

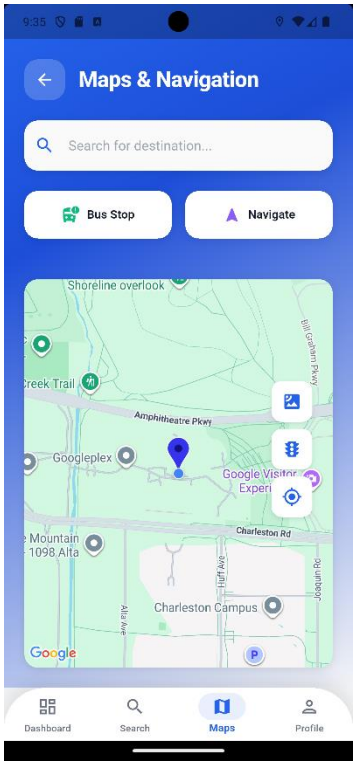

Give Feedback
Choose your bus and share feedback
View Feedback History
Check your previous feedback and status
Select Bus
Select Bus
Choose from available buses
Scan QR
Scan bus QR code
Recent Buses
Bus NB-9999
Galle - Ambalangoda
Bus NB-6576
Colombo-Kandy

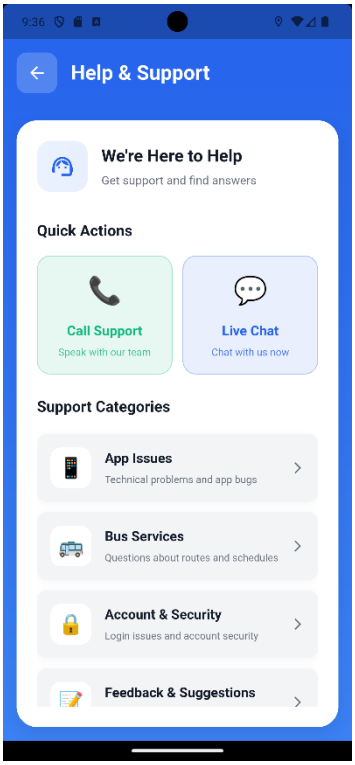

Scan QR Code
Scan the QR code on the bus
Point your camera at the bus QR code
The QR code is usually located inside the bus
Back

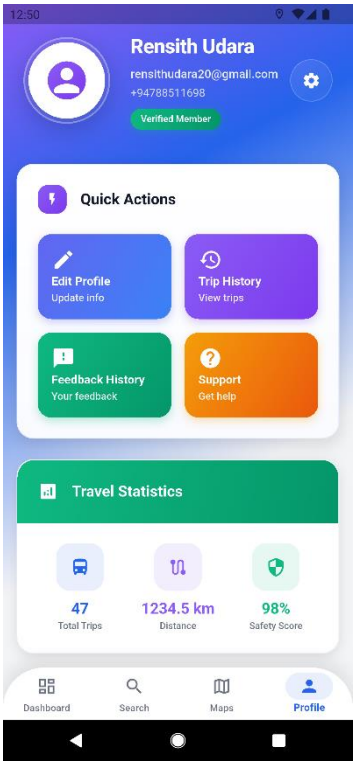

Bus NB-6576 Feedback
Share your travel experience
Bus NB-6576
Selected for feedback
What would you like to give feedback about?
Bus Behavior
Cleanliness, condition, comfort, facilities
Driver Behavior
Driving skills, courtesy, professionalism


Bus Feedback
Share your experience
Bus NB-6576
Bus Feedback
Rate your experience
How would you rate the overall condition and comfort of the bus?
Quick Feedback (Select Multiple)
Choose one or more options that match your experience
Clean and comfortable
Good condition
Air conditioning works well
Submit Feedback


Driver Feedback
Share your experience
Bus NB-6576
Driver Feedback
Rate your experience
How would you rate the driver's performance and professionalism?
Quick Feedback (Select Multiple)
Choose one or more options that match your experience
Excellent driving
Courteous and helpful
Safe driving
Professional behavior
Submit Feedback







Summary of Chapter 5

This chapter details the current implementation of the embedded monitoring system, authority dashboard, and passenger mobile app. The Raspberry Pi–based monitoring prototype uses Python, OpenCV, MediaPipe, YOLOv8 and TensorFlow Lite to achieve real-time detection of drowsiness, distraction, yawning, and smoke with high accuracy and low alert latency. The chapter also describes the NextJS–Firebase authority dashboard with real-time KPIs and fleet tools, and the Flutter-based multilingual passenger app that provides tracking, safety status, feedback, and emergency features, demonstrating an end-to-end working prototype.

6. Project progress and deliverables

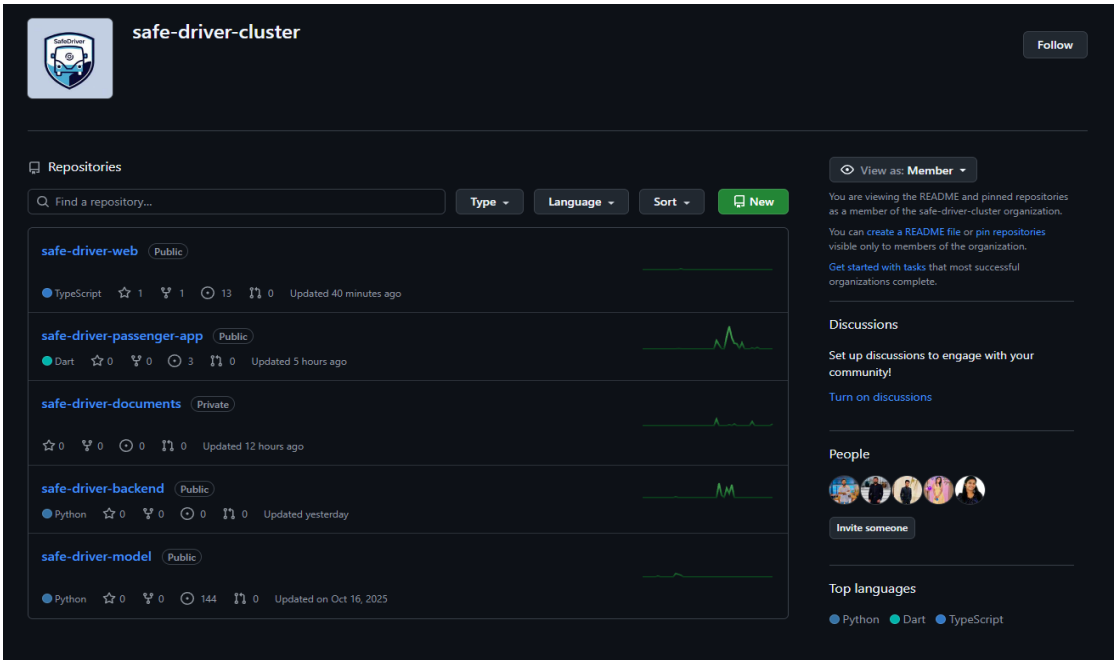
6.1 Design Phase Achievements

- Finalized four-tier system architecture with clear separation of concerns
- Created comprehensive UML diagrams: Use Case, System Architecture, Class Diagram, Sequence Diagram, and Activity Diagram
- Designed UI/UX mockups for dashboard and mobile app using Figma: https://www.figma.com/design/ib3qEk3sChFRF4fi3UuQZ0/Untitled?node-id=1-2
- Documented hardware specifications and GPIO pin configuration
- Established software development infrastructure with GitHub repositories and structured branching

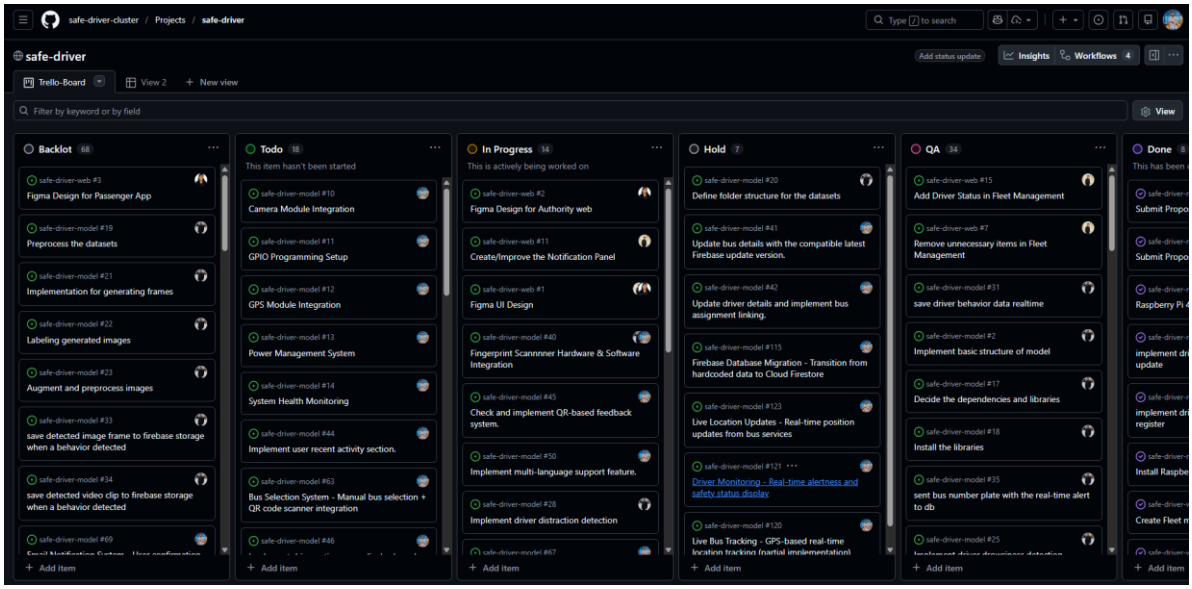
6.2 Development Infrastructure

GitHub Repository: safe-driver-cluster organization with repositories for documents, embedded system, backend, web dashboard, mobile app, and ML models

Link: safe-driver-cluster repositories



Project Management: Trello boards for task tracking organized by status (Backlog, In-Progress, Review, Testing, Completed) Link: https://github.com/orgs/safe-driver-cluster/projects/1/views/1



- Documentation: Version control with tracked revisions and CMMI-compliant meeting minutes
- CI/CD Pipeline: Initial setup for automated testing and deployment

6.3 Team Collaboration

Regular team meetings conducted via MS Teams and Zoom, with documented agendas and action items. Supervisor consultations scheduled bi-weekly to review designs, validate architectural decisions, and provide feedback. All discussions captured in CMMI-compliant meeting minutes for accountability and traceability.

Summary of Chapter 6

This chapter summarizes design-phase achievements, including a finalized four-tier architecture, complete UML diagrams, and Figma UI/UX designs for the dashboard and mobile app. It documents the established infrastructure such as GitHub repositories, Trello boards, meeting minutes, and initial CI/CD pipelines that support structured development. Overall, the chapter shows that the team has laid a solid technical and organizational foundation for subsequent implementation and testing activities.

7. Quality Assurance and Testing Plan

7.1 Testing Strategy

A comprehensive testing strategy aligned with ISO 29119 standards and project requirements:

- Unit Testing: Individual detector and system components with mock data
- Integration Testing: Subsystem interactions and API communication
- System Testing: End-to-end workflows with real hardware
- Acceptance Testing: User acceptance criteria validation
- Performance Testing: Load testing, response time validation, resource utilization

Summary of Chapter 7

This chapter outlines a testing strategy aligned with ISO 29119 and project requirements. It defines multiple test levels, including unit, integration, system, acceptance, and performance testing, to validate detectors, end-to-end workflows, and non-functional criteria such as response time and resource usage. The plan ensures that both functional correctness and performance of the SafeDriver system will be systematically verified before pilot deployment.

8. Challenges And Risk Mitigation

8.1 Identified Challenges

8.1.1 Hardware Performance Constraints

Challenge: Achieving real-time inference (25+ FPS) on Raspberry Pi 4 with limited compute resources.

Mitigation: Implemented quantized, lightweight TensorFlow Lite models; optimized OpenCV operations; profiled and cached results; hardware GPU acceleration where available.

8.1.2 Variable Lighting Conditions

Challenge: Facial detection and eye tracking reliability varies significantly with lighting (night driving, tunnel transitions, glare).

Mitigation: Data augmentation with varied lighting; histogram equalization preprocessing; fallback to alternative detection features; extensive field testing in real conditions.

8.1.3 Data Privacy and Security

Challenge: Capturing and storing video/biometric data while ensuring passenger privacy and data protection compliance.

Mitigation: Edge processing minimizes data transmission; facial data not stored locally; encryption in transit and at rest; GDPR/local compliance audit; user consent mechanisms.

8.2 Ongoing Risk Management

Continuous monitoring of identified risks with quarterly risk reviews. Escalation procedures defined for technical blockers. Contingency plans are prepared for potential hardware delays, regulatory changes, and deployment obstacles.

Summary of Chapter 8

This chapter identifies key technical and non-technical challenges, focusing on hardware performance limits on Raspberry Pi, variable lighting conditions, and data privacy and security concerns. It describes mitigation strategies such as using quantized TensorFlow Lite models, optimized image processing, augmented training data, and strict privacy controls with encryption and edge processing. Ongoing risk management is maintained via continuous

monitoring, escalation procedures, and contingency planning for hardware, regulatory, and deployment risks.

9. Conclusion

Progress Report 2 marks a successful transition from requirements definition to detailed system design. The CodeCrafters team has completed comprehensive architectural design, created detailed UML specifications, developed functional prototypes for core subsystems, and established robust development infrastructure.

The four-tier edge-cloud architecture provides an effective balance between real-time responsiveness and cloud-based scalability. Design pattern implementation ensures code maintainability and extensibility. Prototype demonstrations confirm technical feasibility of key components, including drowsiness detection achieving >80% accuracy and sub-500ms alert response times.

With system design phase complete, the project is well-positioned to enter full implementation and pilot deployment. All major technical risks have been identified and mitigation strategies defined. Team infrastructure and collaborative processes support efficient development. The next phase will focus on code implementation, integration testing, and preparation for real-world pilot validation.

SafeDriver represents a significant contribution to public transportation safety through accessible, intelligent driver monitoring. Successful pilot deployment will demonstrate viability for fleet-wide adoption and potential scaling to other transport operators.

10. References

[1] International Organization for Standardization. (2013). ISO/IEC 27001: Information security management. Retrieved from https://www.iso.org/standard/54534.html

[2] International Organization for Standardization. (2018). ISO 26262: Road vehicles – Functional safety. Retrieved from https://www.iso.org/standard/68383.html

[3] Institute of Electrical and Electronics Engineers. (2008). IEEE 829: Standard for Software and System Test Documentation. Retrieved from https://standards.ieee.org/standard/829-2008.html

[4] National Transport Commission, Sri Lanka. (n.d.). Road Transport Regulations and Safety Standards. https://www.ntc.gov.lk

[5] Ministry of Transport, Sri Lanka. (n.d.). Public Transport Policy Framework. http://www.transport.gov.lk

[6] Google. (n.d.). TensorFlow Lite Documentation. Retrieved from https://www.tensorflow.org/lite

[7] Google. (n.d.). Firebase Documentation. Retrieved from https://firebase.google.com/docs

[8] Google. (n.d.). MediaPipe Documentation. Retrieved from https://mediapipe.dev

[9] OpenCV. (n.d.). OpenCV Documentation. Retrieved from https://opencv.org

[10] Flutter. (n.d.). Flutter Documentation. Retrieved from https://flutter.dev/docs

[11] Amazon Web Services. (n.d.). AWS CloudFormation Documentation. AWS. https://docs.aws.amazon.com/cloudformation

Code review session for web, mobile and model backend projects

Meeting Information			
Meeting Date/Time	20/11/2025 23:00:00		
Participants	D. S. Sandeepa R. U. Gonalagoda P. S. Ekanayaka		
Estimated Time	3h	**Actual Time**	4h
Special Notes	Code review session for web, mobile and model backend projects		
Call/Location Information	MS Teams		
Supported Documents			

Agenda: Code review session for web, mobile and model backend projects

Notes/Clarifications:

Meeting Minutes: 4h

Action Items:

Action item	Decision made by
Code review session for web, mobile and model backend projects	D. S. Sandeepa R. U. Gonalagoda P. S. Ekanayaka

Hardware integration & raspberry pi kit setup

Meeting Information			
Meeting Date/Time	23/11/2025 - 15:00:00		
Participants	D. S. Sandeepa R. U. Gonalagoda		
Estimated Time	2h	Actual Time	3h
Special Notes	Hardware integration & raspberry pi kit setup		
Call/Location Information	Physical		
Supported Documents			

Agenda: Hardware integration & raspberry pi kit setup

Notes/Clarifications:

Meeting Minutes: 3h

Action Items:

Action item	Decision made by
Hardware integration & raspberry pi kit setup	D. S. Sandeepa R. U. Gonalagoda

Integration testing web, mobile and model backend

Meeting Information			
Meeting Date/Time	28/11/2025 - 17:45:00		
Participants	D. S. Sandeepa R. U. Gonalagoda P. S. Ekanayaka T. P. Denagamage		
Estimated Time	4h	Actual Time	4h
Special Notes	Integration testing web, mobile and model backend		
Call/Location Information	MS Teams		
Supported Documents			

Agenda: Integration testing web, mobile and model backend

Notes/Clarifications:

Meeting Minutes: 4h

Action Items:

Action item	Decision made by
Integration testing web, mobile and model backend	D. S. Sandeepa R. U. Gonalagoda P. S. Ekanayaka T. P. Denagamage

Progress tracking meeting with supervisor

Meeting Information			
Meeting Date/Time	28/11/2025 - 21:45:00		
Participants	D. S. Sandeepa R. U. Gonalagoda P. S. Ekanayaka T. P. Denagamage		
Estimated Time	1h	Actual Time	1h 15m
Special Notes	Progress tracking meeting with supervisor		
Call/Location Information	Zoom		
Supported Documents			

Agenda: Progress tracking meeting with supervisor

Notes/Clarifications:

Meeting Minutes: 1h 15m

Action Items:

Action item	Decision made by
Progress tracking meeting with supervisor	D. S. Sandeepa R. U. Gonalagoda P. S. Ekanayaka T. P. Denagamage

Discuss and prepare usecase, system architecture, class, activity, sequence diagrams for safedriver system

Meeting Information			
Meeting Date/Time	14/01/2025 19:30:00		
Participants	D. S. Sandeepa R. U. Gonalagoda		
Estimated Time	1h	Actual Time	1h 30m
Special Notes	Discuss and prepare usecase, system architecture, class, activity, sequence diagrams for safedriver system		
Call/Location Information	MS Teams		
Supported Documents			

Agenda: Discuss and prepare usecase, system architecture, class, activity, sequence diagrams for safedriver system

Notes/Clarifications:

Meeting Minutes: 1h 30m

Action Items:

Action item	Decision made by
Discuss and prepare usecase, system architecture, class, activity, sequence diagrams for safedriver system	D. S. Sandeepa R. U. Gonalagoda

Discuss about the progress 2 report and presentation

Meeting Information			
Meeting Date/Time	11/03/2025 17:30:00		
Participants	D. S. Sandeepa R. U. Gonalagoda P. S. Ekanayaka T. P. Denagamage K. J. L. Perera		
Estimated Time	4h	Actual Time	5h 15m
Special Notes	Discuss about the progress 2 report and presentation		
Call/Location Information	MS Teams		
Supported Documents			

Agenda: Discuss about the progress 2 report and presentation

Notes/Clarifications:

Meeting Minutes: 5h 15m

Action Items:

Action item	Decision made by
Discuss about the progress 2 report and presentation	**All participants**